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By JOSEPHINE F. L. HART

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Introduction

Shrimps of the genus *Betaeus* are members of the section Caridea and the family Alpheidae (or Crangonidae in much of the North American literature). Members of this genus are characterized by the lack of a rostrum in the adult and by the inversion of the "hands," with the result that the dactyls are on the lower side. The terms "visored shrimps" and "hooded shrimps" are sometimes used because the carapace projects forward to overhang the eyes. Up to the present time four species have been recognized as occurring in the area from Mexico to Alaska: *Betaeus harrimani* Rathbun, *B. longidactylus* Lockington, *B. ensenadensis* Glassell, and *B. harfordi* (Kingsley). However, these species have not been well defined.

The sole published record of *Betaeus harrimani* is the original description by M. J. Rathbun (1904) based on a single female taken in southern Alaska. The examination of a series of both males and females from a number of more southerly locations has made it possible to elaborate on this description. Such an elaboration is especially

693-433—63——1

important because of the overlap of the range of the closely allied form *B. longidactylus* Lockington (1877) in California. These two species, as well as *B. ensenadensis* Glassell (1938) of southern California and Mexico, are figured and redescribed here in some detail.

In the 1870's W. N. Lockington and J. S. Kingsley each described two species of hooded shrimps from California. They engaged in considerable controversy in their papers as to whether or not *Betaeus* was a valid genus, and occasionally they referred species of *Betaeus* to the genus *Alpheus;* as a result, in the literature both *Alpheus* and *Betaeus* are used in referring to these shrimps. Lockington (1877b, 1878) described two species briefly, without figures, and, unfortunately, named one *Betaeus equimanus,* a name that had been used previously by Dana (1852, p. 560; 1855, pl. 35) for a shrimp from New Zealand. Early in 1878 Kingsley published a description of apparently the same shrimp and called it *Alpheus harfordi* but indicated that if "*aequimanus*" should prove to be different, the shrimp would have to be called "*aequalis.*" Later in the same year Lockington called it *B. equalis* and enlarged his description by incorporating Kingsley's description of *B. harfordi.* He was convinced that they were identical but because of his use of a preoccupied name, he lost the honor of naming the species. *Betaeus harfordi* (Kingsley) is therefore the valid name.

Holmes (1900) gave a description with more details than those given by the early writers, but unfortunately he added new habitats that perhaps have helped to mask the presence of four distinct forms: two commensal and two free-living.

In 1934 several hooded shrimps were taken in tide pools on the west coast of Vancouver Island by E. G. Hart. These agreed with published descriptions of *B. harfordi* except for a few minor differences. Since shrimps of the family Alpheidae often show considerable variation in relative proportions according to age and sex, no suspicion of significant differences arose until individuals from California were compared with the northern specimens. As a result of a detailed comparative study, it now seems that those found commensal within the mantle cavity of abalones are referable to *B. harfordi* and that the remainder represent three undescribed species. The similar, but quite distinct, form that lives in association with sea urchins I propose to call *B. macginitieae* in recognition of Nettie MacGinitie, who, with her husband Professor G. E. MacGinitie, has contributed so much to our knowledge of the genus. For the two free-living forms I have chosen the names *B. gracilis* and *B. setosus.*

In view of the fact that the published descriptions and figures of the known species are inadequate, an attempt is made herewith to supplement them with more detailed descriptions and illustrations.

The figures are drawn to three magnifications: scales A, B (two times A), C (ten times A). The whole animal, the chelipeds, and chelae are scale A; the dactyli, scale C; and the remainder, scale B. New keys and comparative tables incorporating the new species are presented. In this aspect the work of L. B. Holthuis (1952) on two species found in Chile has been very useful.

In classification, emphasis in the past has been placed on the proportions of the segments of the antennular peduncle, and on the size, shape, and dentition of the large chelae. These features, however, have been found to differ with age, sex, and extent of regeneration. In this paper, therefore, an attempt is made to use as diagnosis those characters that do not vary appreciably during the life of the individual.

Sexual dimorphism also is noted in this account. Differences due to sex are most obvious in large males of *B. longidactylus*, in which the chelipeds are much larger in relative proportion to the rest of the body than in smaller males or in females. All the other species dealt with here also show sexual dimorphism but only to a minor extent such as stouter appendages and narrower pleura on the abdomens of the males.

Acknowledgments

My thanks are due to Dr. Waldo L. Schmitt and Dr. Fenner A. Chace, Jr., of the United States National Museum for the loan of comparative material, for making comparisons with the type of *B. harrimani*, and for much other help. In addition, Dr. Chace read the manuscript and gave invaluable advice. The late Dr. Belle A. Stevens was most helpful in the early stages of the study. I wish also to thank both Dr. Paul L. Illg of the Department of Zoology, University of Washington, and Mrs. G. E. MacGinitie, retired from Kerckhoff Marine Laboratory, for much help and encouragement, as well as for specimens. Thanks also are due to Mr. Keith W. Cox, California Department of Fish and Game, who has given me specimens and much useful data on *Betaeus harfordi* obtained in connection with his work on *Haliotis*.

For the use of material I am indebted to the following: Mr. T. H. Butler and the Fisheries Research Board of Canada; Dr. Joel W. Hedgpeth (Pacific Marine Station); Dr. Rolf Bolin and Dr. Donald P. Abbott (Hopkins Marine Station); Dr. Olga Hartman (University of Southern California, Allan Hancock Foundation) for the loan of the late S. A. Glassell's collection; Dr. James E. Lynch (University of Washington) for collections by Dr. John S. Laurie; and Dr. R. U. Gooding of the University of Washington at the time.

I am also indebted to Mr. C. B. Howland, Victoria, British Columbia, whose patience and ingenuity resulted in successful photographs of the living shrimps. I am grateful also to the Provincial Museum of British Columbia for the use of certain facilities and to the National Science Foundation for a grant providing equipment and aid in the completion of the study. Finally, I want to thank my husband, Dr. G. Clifford Carl, for his help in so many ways.

In addition to the above material I have examined nearly 200 specimens (mainly *B. longidactylus*) from the collection of the Allan Hancock Foundation. I hope to report on this material in a future paper.

Family Alpheidae

Rostrum, if present, unarmed. Eyes usually covered by carapace. Mandibles with incisor process and palp of two segments. First pair of legs often with one chela, or both chelae, powerfully developed. Second pair of legs minutely chelate, long, slender, equal, with segmented carpus. Telson usually broad, rounded.

Genus *Betaeus* Dana

Rostrum not present; front not spined, either emarginate between eyes or evenly rounded. Chelae usually similar, inverted so that dactyls are on lower side. Telson broad. Sixth abdominal somite with movable plate articulated at posterolateral angle. Epipods on at least first two pairs of legs.

Key to Species of *Betaeus* from West Coast of North America

1. Dactyli of walking legs slender and simple 2
   Dactyli of walking legs stout and bifid 4
2. Chelae of first legs with fingers longer than palm.
   B. longidactylus Lockington
   Chelae of first legs with fingers not longer than palm 3
3. Blade of antennal scale broad distally. Fixed finger of first cheliped decreasing in width evenly to sharp curved tip . . **B. harrimani** Rathbun
   Blade of antennal scale narrow distally. Fixed finger of first cheliped truncate before sharp curved tip . . . . . **B. ensenadensis** Glassell
4. Front curved, not emarginate . . . . . **B. macginitieae,** new species
   Front emarginate 5
5. Emargination shallow. Telson with posterolateral spines small or missing.
   B. harfordi (Kingsley)
   Emargination deep. Telson with posterolateral spines well developed . . 6
6. Peduncle of antennule less than one-half carapace length. Merus of cheliped with lower inner ridge with long bristles, upper ridge ending in sharp tooth; chela with fingers subequal to palm; chela is three times as long as wide.
   B. gracilis, new species
   Peduncle of antennule subequal to carapace length. Merus of cheliped with lower inner ridge usually tuberculate, upper ridge with tuft of hairs; chela with fingers longer than palm; chela is twice as long as wide.
   B. setosus, new species

Betaeus harrimani Rathbun

FIGURES 1–26, 29–31, 37–39; PLATE 1

Betaeus harrimani Rathbun, 1904, pp. 108–110, fig. 49 (type locality, Sitka, Alaska; holotype female, USNM 25692).—Banner, 1953, p. 5.

FEMALE.—Carapace laterally compressed but without carina. Smooth, with minute setae sparsely scattered except where concentrated ventral to hepatic region, where they form a pubesence (seen best in cast skins of large individuals). Longer setae under front and along posterior margin. Front (fig. 17) slightly curved and depressed anteriorly. Anterior margin (fig. 18) with two shallow sinuses. No distinct anterolateral angle. Width of carapace increases to midlateral point and then decreases slightly with faint undulations on margin. Lateral margin joins posterior in smooth curve. Posterior margin angles in sharply to deep cardiac notch.

Abdomen (fig. 1) smoothly rounded with posteroventral margin of pleura of first to third segments rounded, those of fourth and fifth segments angled. First and fifth pleura margined with setae ventrally. Minute setae on smooth surface.

Telson (fig. 26) longer than sixth abdominal segment, much longer than wide, outer margins curved. Two pairs of movable spines on dorsal surface, two spines at each posterolateral angle; outer ones small. Posterior margin deeply curved, plumose setae long.

Eye round with short, sharp-pointed tooth on each stout eyestalk medially.

Antennule with stylocerite broad at base; outer margin slightly convex, inner concave, tip reaching almost to end of second segment of peduncle. First segment of peduncle with sharp compressed tooth ventrally (fig. 2). Second joint usually longer than third. Outer flagellum with sensory part fused except for about three segments that are free from slender terminal flagellum.

Antenna with peduncle slightly longer than that of antennule. Distal margin of basis produced into sharp-pointed flat tooth ventrally. Scale (fig. 19) broad: wide spine exceeding blade, separated from it by short slit distally, outer margin straight. Tip reaching past middle of last segment of antennular peduncle. Flagellum longer than carapace, ovoid in cross section.

Mandibles, maxillules, maxillae, first and second maxillipeds (figs. 3–7) similar to those of *Betaeus truncatus* Dana, as described by Holthuis (1952), but appearing more setose, as illustrated.

Third maxilliped (fig. 8) reaching to end of antennal peduncle. Ischiomeropodite flattened, twisted. Exopodite longer than ischiomeropodite but narrow, fragile-looking, with soft plumose hairs distally and striations on cuticle that can be observed in cast skins.

TABLE 1.—*Distinguishing characters*

Characters	*B. harrimani*	*B. longidactylus*	*B. ensenadensis*
abdomen			
ventral pleural margins	1st and 5th setose	same	1st only setose
telson	wide distally	same	narrow distally
antennule			
2nd segment of peduncle	longer than 3rd	subequal to 3rd	much longer than 3rd
stylocerite	nearly to end of 2nd segment	same	to middle of 2nd segment
antenna			
scale	wide distally, distinct slit	same	narrow distally, minute slit
flagellum	slender, oval in cross section	stout, oval	stout, flattened, oval
1st leg			
merus	stout, flared distally	slender, not flared	stout, slightly flared
chela			
length	more than carapace	less than carapace (except large males)	less than carapace
fingers	shorter than palm	longer than palm	shorter than palm
large tooth	on fixed finger	same	on dactylus
2nd leg			
fingers	shorter than palm	subequal or longer than palm	subequal to palm
3rd and 4th legs	slender	relatively stout	slender
ischium	no movable spine	same	movable spine
merus	slightly dilated	same	dilated, flattened
propodus			
ventral spines	slender	stout	very slender
terminal spines	⅓ dactylus	½ dactylus	⅛ dactylus
dactylus	long, thin, curved	shorter, stouter, straighter	very long, thin, curved
length	40% propodus	30% propodus	60% propodus
uropod			
peduncle	2 large teeth with bristles on curved margin between	same	2 small teeth with serrate setae on straight margin
exopodite	tooth above spine	same	tooth and spine widely separated

TABLE 2.—*Distinguishing characters*

Characters	*B. harfordi*	*B. macginitieae*	*B. gracilis*	*B. setosus*
setae	few	very few	few, small, scattered	numerous
carapace	⅓ or less of total length	more than ⅓ total length	⅓ total length	¼ or more of total length
front	emarginate, shallow groove between eyes	not emarginate, slightly convex	emarginate, deep groove between eyes	same
abdomen				
5th pleura	blunt angles posteriorly	roundly acute posteriorly	sharp angle posteriorly	same
telson				
posterolateral spines	very small or missing	small	large	same
antennule				
peduncle	equal to ½ carapace length	same	less than ½ carapace length	subequal to carapace length
2nd segment	1½ times third segment	nearly two times third	1⅓ times third	more than 1½ times third
antenna				
blade	narrow distally, as wide as spine	same	not narrow distally, more than twice width of spine	narrow distally, about twice width of spine
3rd maxilliped	to distal ½ of 2nd segment of antennular peduncle	same	to end of 3rd segment of antennular peduncle	same
1st leg				
merus	very few setae	same	very few setae	many setae
chela	female: equal to, or less than, carapace length male: equal to, or more than, carapace length	female: less than carapace length male: greater than carapace length	subequal to carapace length	greater than carapace length
gape	female: little or none male: usually a foramen	small, relatively narrow	small or none	female: often none male: large
fingers	equal to, or slightly longer than, palm	shorter than palm	shorter than palm	longer than palm
setae	on cutting edges only	same	only on cutting surfaces and fingers	on cutting edges and margins of chela
uropod				
teeth on peduncle	subequal, no setae, or minute between	very small, no setae	outer slightly larger, few setae between	outer much larger, long stiff setae between
habitat	within mantle cavity of abalone	beneath sea urchins	free-living	same

Penultimate segment short, less than ½ length of distal segment, which has rows of stout bristles medially.

First leg large, usually nearly twice length of carapace, with chela as long as, or longer than, carapace. Ischium short. Merus shorter than chela, somewhat triangular in cross section, distal margin rounded; ventral with two tuberculate ridges separated by shallow sinus. Outer ridge protruding distally to form broad flat process. Outer surface of merus with broad, oblique sinus, devoid of tubercles, into which second leg may fit. On inner surface a longitudinal sinus and distally a deep transverse groove. Large membranous area ventrally into which flat, platelike toothed process of carpus fits. Scattered tubercles over most of surface. Carpus short, rounded dorsally, with transverse and longitudinal sinuses. Chelae (figs. 11, 13, 14, 30, 31) finely tuberculate, spinulate, with fine pubescence, especially dorsally. Not compressed but somewhat flattened on inner side of palm. Great variation in proportion, length, width, dentition of palm and fingers. Fingers occasionally subequal to palm but usually about ½ as long. Gaping, large-toothed type much more common than nongaping, finely denticulated form described by Rathbun (1904). (There can be no doubt that both types are found in *B. harrimani*, as a number of specimens have one chela of each type. One such, kept in the laboratory, had the chelipeds injured and the regenerated chelae both had nongaping fingers). Tips of fingers curved, with chitinous parts interlocking.

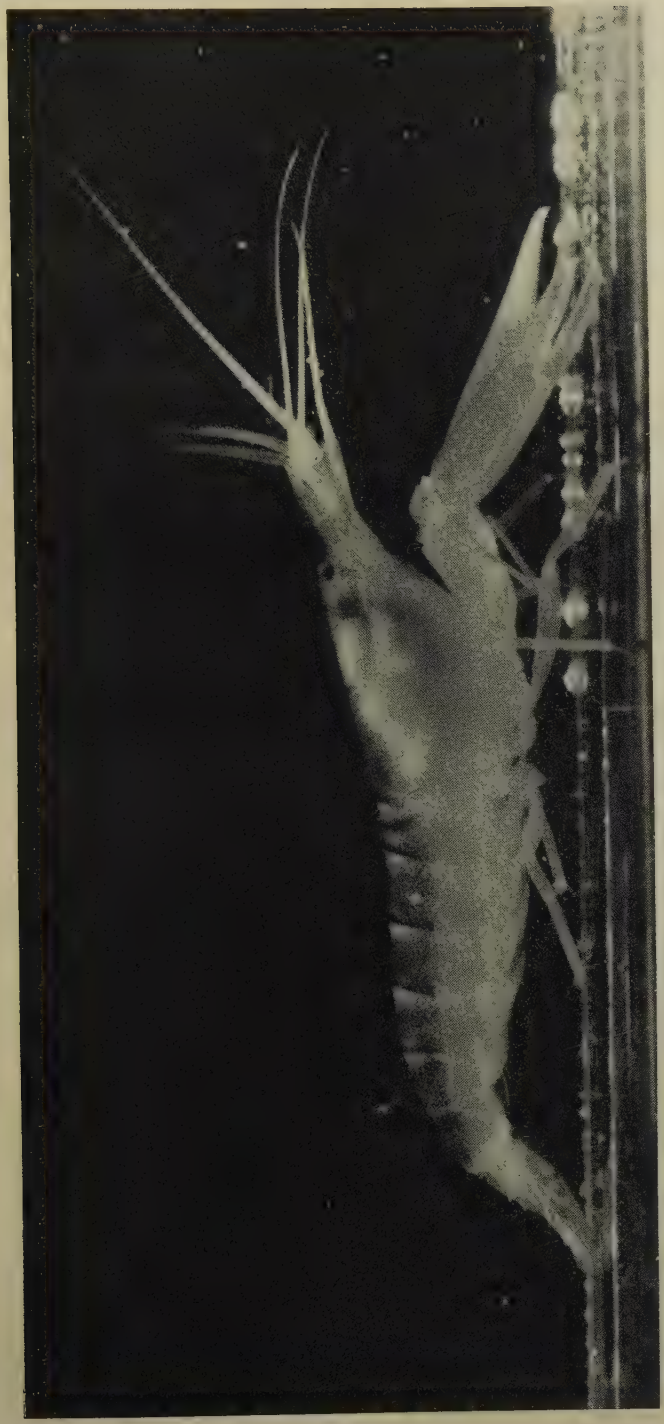
Second leg (fig. 37) very slender, with elongated ischium, nearly as long as 5-jointed carpus, longer than merus. First joint of carpus equal in length to next three together, or to chela; second slightly longer than subequal third and fourth; fifth, twice fourth. Chelate, with palm longer than fingers, tips setose.

Third and fourth legs (figs. 9, 38) slender, somewhat flattened. Ischium subequal to carpus, about ½ length of merus. Merus slightly inflated, with movable spine. Carpus with two ventral terminal spines. Propodus with ventral marginal spines and setae: terminal pair stout, and group of bristles dorsally. Dactylus (fig. 39) curved, thin, sharp-pointed, with curved setae dorsally; more than ⅓ length of propodus, which is nearly as long as merus.

Fifth leg (fig. 10) similar in size and spinulation to third and fourth, but with transverse bands of setae forming brush on distal half of propodus.

First pleopod with small, sparsely setose endopodite. Second to fifth with endopodite and exopodite subequal. Appendix interna straplike.

Uropod (fig. 26) with distal margin of peduncle scalelike, produced into two subequal teeth, curved margin between armed with long



Betaeus harrimani Rathbun, male, photograph of living animal.

Betaeus setosus, new species, female, photograph of living animal.

bristles. Median to these another tooth. Distal angle of outer margin of proximal part of exopodite a sharp tooth, covering base of stout spine; distal margins rounded, with bristles as well as plumose setae. Bristles dorsally on margin of exopodite, scattered over dorsal surface of endopodite. Exopodite and endopodite nearly equal in size, longer than telson but about same width.

Male.—Similar to female except that carapace and abdomen slightly more slender, pubescence on carapace thicker, setae on margin of first pleura sparser. Antennular peduncle with middle segment usually distinctly longer than that of females of comparable size. Chelae usually longer than carapace, with same range of variation as females but often somewhat wider, stouter, as are walking legs. Second pleopod (fig. 16) with appendix masculina only slightly longer than appendix interna, bearing brush of terminal setae.

Color.—The living animal (pl. 1) is transparent, except for chromatophores which occur in a distinct pattern. The color consists of small red chromatophores usually surrounded by dark blue spots. The pigmented areas of the carapace are two broad bands on the dorsal part separated by a thin middorsal line that is unpigmented except between the eyes. Two colored patches occur on the carapace at the base of the antennae. In the female the green eggs in the ovary may show through the integument. The abdomen also is pigmented dorsally and, except for the first segment, the segments are clear anteriorly and middorsally but deeply colored in a band posteriorly at the joints. The lateral part of the sixth abdominal segment often is pigmented as is the telson, which, however, has a light streak. There is a fine band of color near the anterior margin of the tergum of the first segment.

The eyestalks, antennules, and antennae are heavily pigmented. The flagella are reddish. The mouth parts are clear except for the third maxillipeds, which have scattered spots. The chelipeds are well colored, mainly red, but the tips of the claws are clear. The second pair of walking legs is clear, but the rest have scattered red dendritic chromatophores. The uropods are mainly red but the setae are creamy white.

The color ends in a straight line midlaterally and the ventral parts are quite transparent. The coloration varies with the state of the chromatophores. By day, when the red chromatophores are expanded, the animal is reddish or purplish; by night it is distinctly blue. One specimen, after preservation, turned a uniform pale green. The color recorded by Rathbun (1904) is "light green."

Size.—Carapace length of smallest ovigerous female 5.5 mm.; largest female 12.5 mm.; males 2.5–13 mm. Length of chela of largest female 10.5 mm.; largest male 14 mm.

RANGE.—Newport Harbor, Calif., to Sitka, Alaska.

HABITAT.—Intertidal, possibly partly commensal in the burrows of the mud shrimp *Upogebia pugettensis* (Dana) or the ghost shrimp *Callianassa californiensis* Dana. Individuals have been collected from pools formed in the depressions left by boulders on a gravelly beach; the openings of the burrows of the mud shrimps occur in the sides of these pools. Others have been found by chance when excavations were being made for mud or ghost shrimps, and one was found out of water between two slabs of sandstone. In only one locality have the shrimps been found in any numbers: in the oyster dike area of Oakland Bay, Puget Sound, where they were under logs, shells, and debris near the low tide mark, and in the trickle of water leaking from dikes (Dr. J. S. Laurie).

MATERIAL.—The following specimens were examined:

CALIFORNIA.—Newport Harbor, N. MacGinitie, 1 male.—Monterey Bay, Elkhorn Slough, Aug. 2, 1927, G. E. MacGinitie, 1 ovigerous female (Hopkins Marine Station).—Monterey Bay, in muddy sand with *Upogebia*, July 3, 1951, C. Hand, 1 male (USNM 92660).

WASHINGTON.—Willapa Bay, muddy sand, in burrow of *Callianassa californiensis* Dana, May 4, 1958, F. Clogston and R. U. Gooding, 1 male.—Puget Sound: Oakland Bay, near Shelton, in oyster dikes under wood debris, June 28, 1942, A. H. Banner, 1 ovigerous female; Oakland Bay, shore, Sept. 26, 1951, J. S. Laurie, 1 female, 1 male; Oakland Bay, from under board, Aug. 4, 1952, J. S. Laurie, 1 male; Oakland Bay, Aug. 19, 1952, J. S. Laurie, 2 males; Oakland Bay, State Reserve Dikes, Sept. 16, 1952, J. S. Laurie, 43 females (1 ovigerous), 26 males, 1 juvenile; Oakland Bay, Ersudt's Ground, Nov. 2, 1952, J. S. Laurie, 9 females, 7 males; Seabeck, Sept. 18, 1928, 1 female; Warm Beach, June 8, 1931, 1 male.—San Juan Archipelago: San Juan Island, Kanaka Bay, with *Callianassa californiensis* Dana, July 31, 1956, R. U. Gooding, 1 ovigerous female; San Juan Island, Garrison Bay, with *Upogebia pugettensis* (Dana), Aug. 22, 1957, R. U. Gooding, 1 male; Brown Island, with *Upogebia pugettensis* (Dana), July 13, 1961, J. F. L. Carl, 1 male.

BRITISH COLUMBIA.—Victoria: Cadboro Point, under boulder, April 7, 1950, J. F. L. Carl, 1 female; Cadboro Point, in pool formed while digging for mud shrimps, July 27, 1958, G. C. and J. F. L. Carl, 1 ovigerous female, 1 male.—East coast of Vancouver Island: Departure Bay, north of Nanaimo, from stomach of flounder, *Pleuronichthys coenosus* Girard, July 9, 1934, E. Kuitenen, 1 ovigerous female (damaged); Departure Bay, under boulders, July 29, 1938, J. F. L. Carl, 3 females (2 ovigerous); Departure Bay, Aug. 8, 1938, J. F. L. Carl, 1 female; Departure Bay, Aug. 10, 1938, J. F. L. Carl, 3 females, 2 males; Departure Bay, Aug. 24, 1938, J. F. L. Carl, 5 females, 2 males; Departure Bay, March 23, 1939, J. F. L. Carl, 1 female, 1 male; Hammond Bay, north of Nanaimo, muddy gravel, with *Upogebia pugettensis* (Dana), June 22, 1962, J. F. L. Carl, 11 females (3 ovigerous), 8 males; Hornby Island, between slabs of sandstone, July 7, 1959, A. D. Carl, 1 male.—West coast of Vancouver Island, Clayoquot Sound, near Kakawis, Meares Island, June 14, 1946, E. F. Ricketts, 1 male (USNM 84397); Kyuquot, mudflat pool, July 10, 1958, G. C. Carl, 1 ovigerous female.

NOTES.—This is a very agile shrimp, inclined to "play possum" and then to move very quickly. Even in clear water, to see the animal

is difficult because of its protective coloration and transparency. The shrimp is so striking in appearance, however—with its large chelipeds and lobster-like form—that specimens found incidentally when other animals are being collected are not likely to be discarded. Yet there are very few preserved specimens even from areas where the fauna is well known. Is it, therefore, really rare or only rarely found? Dr. J. S. Laurie, collecting in Oakland Bay, Puget Sound, seems to be the sole person to have obtained the shrimps in any number, and this was done only over a period of more than one year. Subsequent searching by other workers in the same area has not been productive.

Rathburn (1904) described *Betaeus harrimani* from a single female found at Sitka, Alaska. With the exception of Banner's comment (1953) on the far northern habitat, I am unaware of any other reference to the species in the literature. The present specimens agree with Rathbun's description except in a few minor details. The palm of the second leg seems to be appreciably longer than the fingers, not subequal as she stated, and the posterolateral angles of the fourth and fifth abdominal pleural segments are square, rather than rounded. The proportionate length and width of the palm, the presence of large teeth on the fingers, and the gape differ radically from the finely denticulated, nongaping type she described. There is little doubt that all specimens in the present collections are *B. harrimani* because, although in many specimens both chelae are very different, others have one chela denticulate and nongaping and the other chela toothed and gaping.

Ovigerous females have been found in the field June–September and in the laboratory December–July. The eggs are a bright green when first extruded but become brownish and more transparent before hatching.

Betaeus longidactylus Lockington

FIGURES 20–22, 27, 32–34, 40–42

Betaeus longidactylus Lockington, 1877a, p. 35 (type locality, San Diego, California; holotype not extant); 1878, p. 480.—Rathbun, 1904, p. 108.—Baker, 1912, p. 106.—Hilton, 1916, p. 67.—Schmitt, 1921, p. 80, pl. 12; 1924, p. 387.—Johnson and Snook, 1927, p. 310, fig. 262.—MacGinitie, 1930, p. 68; 1935, p. 658, 660, 686, 705–706; 1937, p. 1035.—MacGinitie and MacGinitie, 1949, p. 279.—Ricketts and Calvin, 1952, p. 42, fig. 18.

Alpheus longidactylus Kingsley, 1878a, p. 198.—Holmes 1900, p. 190.

FEMALE.—Carapace laterally compressed but without carina. Smooth, with very fine scattered setae somewhat concentrated over branchial region. Longer setae on posterior margin. Front (fig. 20) straight, depressed anteriorly, slightly swollen over eyes. No distinct junction with lateral margin (fig. 21). Width of carapace increases rapidly so that most of carapace subequal in width, but

lateral margin somewhat undulate. Posterolateral margin curved, posterior margin angled below deep cardiac notch.

Abdomen smoothly rounded, with posteroventral margins of first to third segments rounded, those of fourth and fifth angled. First and fifth pleura ventrally margined with plumose setae. Minute setae on smooth surface.

Telson (fig. 27) longer than sixth abdominal segment, nearly twice as long as wide, outer margin slightly undulate. Two pairs of movable spines on dorsal surface, two spines on each posterolateral angle; outer spines very small. Posterior margin deeply curved; plumose setae relatively short.

Eye round. Sharp cone-shaped tooth on median part of short, stout eyestalk.

Antennule with stout peduncle of three subequal segments. Broad-based scimitar-shaped stylocerite reaching almost to end of second segment. Outer flagella with stout fused portion before division into short sensory part and much longer, slender flagellum. Peduncle with large tooth ventrally.

Antenna with stout peduncle slightly longer than antennular peduncle. Distal margin of basis produced into sharp tooth. Scale (fig. 22) broad; wide spine exceeding blade, and separated by distinct slit distally, outer margin straight. Scale reaches nearly to end of antennular peduncle. Flagellum longer than carapace, flattened ovoid in cross section.

Third maxilliped reaching to last segment of antennular peduncle. Ischiomeropodite flat, relatively narrow, curved over mouth parts, slightly shorter than exopodite, about twice as long as ultimate, four times penultimate segment. Medial surfaces all armed with bristles, which are particularly dense on distal segment.

First legs (fig. 32) usually similar in size and shape, with chela much shorter than carapace. Ischium short. Merus slender, increasing in size distally, somewhat triangular in outline with scattered tubercles. Shallow groove on outer side where second leg fits. Carpus short, smooth, cup-shaped, with slight dorsal and larger ventral flattened projection. Chela narrow elongate, covered with fine spines. Fingers longer than palm, narrow gape, with one large flat tooth medially on fixed finger, another proximally, which meshes with similar one on dactylus. Curved corneous tips cross and intermesh. Chela subrectangular, but deepest at base of dactylus. There may not be any large teeth nor any gape when fingers are closed, particularly in small individuals (fig. 33).

Second leg (fig. 40) slender, with ischium subequal to merus. First joint of carpus slightly longer than next three together, subequal to

fifth plus palm. Second joint longer than subequal third and fourth. Fingers subequal to, or longer than, palm.

Third leg (fig. 41) relatively stout, slightly flattened, reaching to fingers of cheliped. Ischium about ⅓ length of merus, which is slightly dilated, has movable spine. Carpus stout, nearly twice length of ischium, with two ventral terminal spines. Propodus elongate, subequal to merus, with double row of spines on ventral margin (terminal pair much stouter than others). Dactylus (fig. 42) stout, with curved corneus tip and bristles on slight elevation dorsally.

Fourth leg very like third but somewhat smaller.

Fifth leg more slender. Ischium about ½ length of merus. Undilated merus with movable spine, longer than propodus, twice as long as carpus. Propodus with transverse rows of bristles distally on outer face as well as double row of spines on ventral margin.

First pleopod with slender endopodite about ½ length of exopodite. Second pleopod with endopodite slightly shorter, narrower than exopodite. Appendix interna straplike.

Uropod (fig. 27) with distal margin of peduncle scalelike, produced into two teeth, outer of which stouter, longer, separated by curved margin armed with long bristles. Another tooth median to these. Proximal part of exopodite with large posterolateral tooth, dorsal to large spine, which is nearly as long as distal section. Dorsal surface of endopodite with bristles, all posterior margins fringed with long plumose setae. Exopodite slightly longer than endopodite, both longer than telson.

Male.—Similar to female except carapace and abdomen slightly more slender and setae on first pleuron sparse, not plumose. Small individuals have chelipeds very like those of females but proportionately somewhat larger. Large males develop very large chelipeds, with wide gape, big teeth, and fingers touching only at the tips (fig. 34). When the carapace length is more than 9 mm., the hand may be longer than the carapace and, in some instances, even 1½ this length. Appendix masculina of second pleopod straplike; terminating in a brush of bristles and somewhat longer than appendix interna.

Color.—Published records give the color of the living animal as olive-green, olive-brown, uniform red-brown, or blue-green, with a light middorsal stripe, reddish legs with clear white tips, and dark tail fan with yellow setae.

Size.—Carapace length of smallest ovigerous female 7.8 mm.; largest female 14.5 mm.; males 4–16 mm. Length of chela of largest female 11.3 mm. and of largest male 23.5 mm.

Range.—Tepoca Bay, Gulf of California, Mexico (about 30° N, 113° W) to Elkhorn Slough, Monterey Bay, Calif.

Habitat.—Tide pools, under rocks, in eelgrass, in crevices among

materials on boat bottoms, and paired in burrows of echiuroid worm *Urechis caupo* Fisher and MacGinitie or mud shrimp *Upogebia pugettensis* (Dana).

MATERIAL.—The following specimens were examined:

MEXICO.—San Felipo, May 11, 1937, S. A. Glassell, 1 female.

CALIFORNIA.—San Diego, dredged, March 9, 1949, T. E. Bowman, 2 males (USNM 98059).—La Jolla, from kelp holdfasts on beach, Aug. 28, 1918, W. L. Schmitt, 2 females (USNM 53910).—La Jolla, Sept. 21, 1918, W. L. Schmitt, 1 female, 2 males (USNM 53914).—La Jolla, tide pools, Sept. 22, 1918, W. L. Schmitt, 1 ovigerous female, 9 males (USNM 53925).—La Jolla, Bird Rock, Nov. 3, 1942, 1 female, 1 male (Pacific Marine Station, 846, 847).—La Jolla, kelp beds, March 16, 1954, C. Limbaugh, 1 male (USNM 96415).—Laguna Beach, W. A. Hilton, 1 ovigerous female, 2 males (USNM 48982).—Laguna Beach, W. A. Hilton, 1 ovigerous female, 2 males (USNM 50582).—Laguna Beach, W. A. Hilton, 2 ovigerous females (USNM 50586).—Laguna Beach, W. A. Hilton, 1 male (USNM 50590).)—Laguna Beach, under stones, W. A. Hilton, 1 ovigerous female, 2 males, pale olive-green (USNM 52756).—Newport Bay, Jan. 20, 1929, Dec. 16, 1930, G. E. MacGinitie, 1 female, 1 male, 12 juveniles (Hopkins Marine Station).—Santa Catalina Island, west shore of Catalina Harbor, Dec. 12, 1912, *Anton Dohrn*, 3 females (USNM 49981).—Santa Catalina Island, Nov. 28, 1913, *Anton Dohrn*, 5 females, 10 males (USNM 49980).—Catalina Island, Isthmus Harbor, Nov. 27, 1913, *Anton Dohrn*, 9 females, 8 males (USNM 49982).—Catalina Island, west shore of Catalina Harbor, Nov. 28, 1913, *Anton Dohrn*, 20 juveniles (USNM 50012).—Long Beach, H. N. Lowe, 2 males (USNM 53018).—San Pedro, C. F. Baker, 1 male (USNM 29309).—San Pedro, Rocky Point, Feb. 2, 1912, *Anton Dohrn*, 2 males (USNM 49978).—San Pedro, Portuguese Bend, June 26, 1914, *Anton Dohrn*, 1 male (USNM 49979).—San Pedro, Government Breakwater and Point Fermin, littoral, April 2, 1913, *Anton Dohrn*, 3 females, 6 males (USNM 49983).—San Pedro, first rocks north of Port Los Angeles, Dec. 5, 1911, *Anton Dohrn*, 3 females, 2 males (USNM 49993).—San Pedro, May 4, 1919, E. P. Chace, 1 female (USNM 54048).—San Pedro, June 25, 1895, S. J. Holmes(?), Univ. of California, 20 females (14 ovigerous, 5 parasitized), 6 males (USNM 87439).—Santa Monica, near long wharf, Venice Marine Biological Station, 1 male (USNM 46118).—Santa Monica, April 1923, E. P. Chace, 1 male (USNM 57174).—Morro Bay, Feb. 2, 1939, S. A. Glassell, 1 male.—Santa Monica, 8 miles north, open beach in *Upogebia* burrow, Feb. 2, 1931, G. E. MacGinitie, 1 female (Hopkins Marine Station).—Monterey Bay, Elkhorn Slough, April 3, 1930, G. E. MacGinitie, 1 female (Hopkins Marine Station).

NOTES.—*Betaeus longidactylus* is a stouter species than *B. harrimani* and may be separated easily on the basis of the chelipeds. The ranges overlap in the region from Newport Bay to Monterey, but few specimens of either species are present in collections from this area. Ricketts and Calvin (1952) state that *B. longidactylus* is very plentiful in southern California, where it occurs on the outer coast, but in the northern part of its range the species is restricted to quiet waters. Berried females have been taken in January, June, August, and September.

Betaeus ensenadensis Glassell

FIGURES 23–25, 28, 35, 36, 43–45

Betaeus, new species, MacGinitie, 1934, pp. 173–174; 1937, pp. 1035–1036.
Betaeus ensenadensis Glassell 1938, pp. 416–419, pl. 28 (type locality, Estero de la Punta Banda, Ensenada, Baja California, Mexico; holotype male, San Diego Soc. Nat. Hist. No. 1121).—MacGinitie and MacGinitie, 1949, p. 279.

FEMALE.—Carapace laterally compressed but without carina; smooth, naked. Front (fig. 23) slightly curved, depressed anteriorly. Anterior margin without sinuses or with shallow ones. Anterolateral angle obtuse (fig. 24). Width of carapace increases rapidly to base of third maxilliped, followed by slight undulation over base of first legs. Posterolateral region rounded. Blunt angle beneath cardiac notch.

Abdomen smoothly rounded with posteroventral margins of pleura of first four segments rounded, fifth bluntly angled. Ventral margin of first pleuron sparsely setose.

Telson (fig. 28) subequal to sixth segment, nearly twice as long as wide, with outer margins slightly undulate. Two pairs of movable spines on dorsal surface, two spines at each posterolateral angle, outer ones very small. Posterior margin slightly curved, armed with plumose setae.

Eye somewhat oval, with small flat tooth on eyestalk.

Antennule with stout scimitar-shaped stylocerite, reaching to about distal third of second segment of peduncle. Subterminally first segment of peduncle produced into thin tooth ventrally. Second segment of peduncle longer than first, which is longer than third. Flattened fused part of outer flagella shorter than peduncle; distally divided into few free segments and slender flagellum subequal to fused portion. Inner flagellum considerably longer.

Antennal peduncle subequal to antennular peduncle, with ventral distal part of basis produced into sharp tooth. Scale (fig. 25) with spine much longer than narrow blade, slit between minute; outer margin almost straight. Scale reaching to middle of third segment of antennular peduncle. Flagellum short, wide, much flattened, reaching slightly past posterior margin of carapace.

Third maxilliped reaching to middle of second joint of antennular peduncle. Ischiomeropodite sparsely setose, slender, flattened, somewhat curved, subequal to two distal segments together in length. Exopodite longer than ischiomeropodite, relatively stout. Penultimate segment shortest, sparsely setose. Distal segment banded medially with many short bristles.

First legs (fig. 35) similar. Ischium short with ridge flatly tuberculated ventrally. Stout merus with deep groove into which second leg fits. Two evenly toothed ridges ventrally, transverse sulcus distally.

Carpus short, rounded dorsally, smooth, except for two tubercles or teeth on inner margin. Platelike ridge ventrally with somewhat rough edge. Chela covered with fine denticles, particularly on outer surfaces. Inner side of chela flat, outer rounded. Dactylus slightly shorter than palm, with three teeth: one small, near junction with palm and meshing with similar tooth on fixed finger; large conical tooth near middle; terminal tooth meshing with truncate terminal part of fixed finger. Fixed finger stout with wide cutting surface bordered on each side with denticulated, elevated edge; both fingers end in sharp tips that cross when closed. Distinct gape.

Second leg (fig. 43) slender. Merus and ischium subequal, slightly shorter than 5-jointed carpus, which has first joint longer than fifth and about equal to second, third, and fourth together, which are subequal to each other. Fingers subequal to palm.

Third (fig. 44) and fourth legs flattened with dilated merus. Ischium nearly ½ merus in length. Distinct movable spines on merus and ischium. Sparsely setose; single spine and setae on distal ventral part of carpus, usually three equidistant spines and terminal pair on ventral part of propodus. Few bristles dorsally. Needle-sharp curved dactylus (fig. 45), more than ½ length of propodus.

Fifth leg without movable spine on ischium, but one on undilated merus. Rather sparse brush of bristles on distal part of propodus. Dactylus similar to that of third or fourth leg.

First pleopod with round-tipped endopodite less than ½ length of exopodite. Second to fifth pleopods with exopodite slightly longer than endopodite, both slender. Appendix interna stout and straplike.

Uropod (fig. 28) broad and considerably longer than telson. Peduncle with straight margin; two small teeth separated by serrated spines graduated in length with longest medial. Proximal margin of exopodite with serrated spines of varying lengths forming thatch between small lateral tooth and large distal spine.

Male.—With straight front. Cheliped (fig. 36) proportionately heavier, wider than that of female (median tooth on dactylus may be missing). Appendix masculina on second pleopod only slightly longer than appendix interna, blunt tip armed with bristles of varied lengths.

Color.—"The carapace, abdomen and chelipeds are covered with light tinted chromatophores in reds and blues, the fingers and telson are tinted a light purple" (Glassell, 1938). "Minute red and blue spots" (MacGinitie and MacGinitie, 1949).

Size.—Carapace length of smallest ovigerous female 5 mm.; largest female 7 mm.; males 4.5–6.8 mm. Length of chela of largest female 6 mm.; of largest male 5.6 mm.

RANGE.—El Estero de la Punta Banda, Ensenada, Baja California, Mexico, to False Bay, San Diego, Calif.

HABITAT.—MacGinitie (1937), MacGinitie and MacGinitie (1949), and Glassell (1938) record the shrimps living in pairs in the burrows of the ghost shrimp *Callianassa californiensis* Dana at Ensenada and in the burrows of the mud shrimp *Upogebia pugettensis* (Dana) at San Diego.

MATERIAL.—The following specimens were examined:

MEXICO.—El Estero de la Punta Banda, Ensenada, Baja California, Dec. 19, 1930, G. E. MacGinitie, 1 ovigerous female, 1 male.—El Estero de la Punta Banda, Ensenada, Baja California, Jan. 21, 1932, G. E. MacGinitie, 7 females (1 ovigerous), 3 males.

CALIFORNIA.—Mission Bay, in burrow, December 1949, T. E. Bowman, 1 specimen (USNM 102442).—False Bay, San Diego, with *Upogebia*, Nov. 18, 1937, G. E. MacGinitie, 3 females (1 ovigerous).

NOTES.—A small, slight shrimp of the same type as *Betaeus harrimani* and *B. longidactylus*, but easily distinguished from these by the shape of the antennal scale, the truncate tip of the fixed finger, the large teeth on the dactylus of the chela, the presence of a movable spine on the ischium of the third and fourth walking legs, and the characteristics of the uropod. Ovigerous females have been taken in November, December, and January.

Betaeus harfordi (Kingsley)

FIGURES 46, 47, 54, 58–61, 73, 74

Betaeus equimanus Lockington, 1877b, p. 43 (type locality, Catalina Island, California; types not extant).

Alpheus harfordi Kingsley, 1878a, pp. 198–199 (type localities, Santa Barbara and Catalina Island, California; types not located); 1878b, pp. 58–59; 1882, p. 124, pl. 2, fig. 4.

Alpheus aequalis Kingsley, 1878a, p. 199.

Betaeus aequalis Lockington, 1878, pp. 479–480.

Alpheus (*Betaeus*) *aequalis* Holmes, 1900, p. 189, pl. 3, fig. 47 (part).

Betaeus harfordi Rathbun, 1904, p. 108.—Schmitt, 1921, p. 79, fig. 55.—MacGinitie and MacGinitie, 1949, p. 279 (part).—Ricketts and Calvin, 1952, pp. 323–324 (part).

FEMALE.—Carapace laterally compressed but without carina; smooth, naked. Front (fig. 46) shallowly emarginate, produced to cover eyes. Anterior margin of carapace (fig. 47) shallowly curved, meeting lateral margin at blunt angle just ventral to base of antenna. Width of carapace increasing to base of third maxillipeds, gradually decreasing to curved posterolateral margin. Posterior margin protrudes slightly before decreasing ventral to cardiac notch.

Abdomen smooth, evenly rounded. Naked except for plumose setae on ventral margin of pleura of first segment. Pleura with

posterolateral margins evenly rounded except fifth, which is somewhat acute.

Telson (fig. 58) wide, flat, shorter than uropods. One and one-half to twice length of sixth segment. Lateral margins curved. Distally about ¾ as wide as proximally. Two pairs of small movable spines on distal half of dorsal surface, but posterolateral spines vestigial or missing. Posterior margin curved, bearing long plumose setae.

Eye large, round, on short stalk with small median tooth.

Antennule with stylocerite narrow, sharp-pointed, reaching to distal quarter of second segment of peduncle. Ventrally a slender scimitar-shaped tooth on distal part of first segment of peduncle. Peduncle slender, about ½ carapace length. Second segment about twice length of subequal first and third segments. Flagella slender, short: outer flagella fused for most of length with only terminal tip of sensory part free and remaining flagellum short, slender.

Antenna slender. Peduncle with wide tooth ventrally on margin of first segment; slightly longer than antennular peduncle. Scale (fig. 54) narrow, with stout spine longer than narrow blade, separated from it with slit for about ⅓ of length. Flagellum longer than carapace, ovoid in cross section.

Third maxilliped reaching to end of second segment of antennular peduncle. Relatively narrow, with flattened ischiomeropodite subequal to distal segment, sparsely bristled. Penultimate segment sparsely setose, slightly shorter than distal, which is armed medially with bands of stout bristles and scattered longer setae. Exopodite slightly longer than ischiomeropodite.

First legs subequal, large. Chela slightly shorter than carapace. Ischium short. Merus naked except for few setae on inner margin: triangular in cross section, with dorsal carina smooth, sharp, ending in curved tooth distally, outer ventral ridge smooth, inner one with some flattened tubercles. Carpus short, smooth, naked, cup-shaped with small ventral plate. Chela (fig. 60) smooth, flattened laterally: few fine scattered setae on dorsal ridge, stiff setae near tips of fingers and on cutting surfaces. Palm and fingers subequal but fixed finger much wider than dactylus. Somewhat flattened teeth of cutting surface may mesh without any gape or may have hiatuses on both fingers resulting in a round foramen. Chelae usually alike in dentition. Dorsal ridge of fixed finger and palm compressed, so that margin knife-edged.

Second leg (fig. 61) slender. Ischium longer than merus; both flattened laterally. Carpus with first joint longest, fifth next, others shorter, subequal. Chela longer than first joint, fingers subequal to palm. Cutting surface of fingers spinulate.

Third leg (fig. 73) stout, flattened laterally, with scattered fine

setae. Ischium and merus comprise ½ length of appendage. Large movable spine on merus. Carpus, with minute terminal spines, subequal in length to propodus. Propodus armed ventrally with small setae and vestigial spines. Terminal pair larger. Dactylus (fig. 74) short, stout, bifid, but claws masked by two median bands of short stiff bristles.

Fourth leg similar to third, but all segments except ischium slightly smaller.

Fifth leg distinctly shorter than fourth. Subequal merus and propodus each longer than carpus. Brush of 4–5 bands of short stiff setae on distal part of propodus. Dactylus similar to that of third and fourth legs. No movable spine on merus.

First pleopod with round-tipped endopodite, nearly ½ length and width of slender exopodite. Second pleopod with subequal slender endopodite and exopodite. Appendix interna straplike, nearly ⅓ length of endopodite.

Uropod (fig. 58) with posterior margin of peduncle produced into two sharp subequal teeth, separated by concave margin with few small setae. Distal angle of proximal part of exopodite a sharp tooth, covering base of short stout spine. Uropods longer than telson.

Male.—Similar to female except that chelae (fig. 59) are proportionately larger, subequal in length to carapace. Appendix masculina with bristles on margin of distal half and on blunt tip; twice as long as appendix interna, nearly as long as endopodite.

Color.—Dark purple (Lockington, 1878; Holmes, 1900), blue-black (specimen label, E. P. Chace), deep blue (specimen label, W. A. Hilton) and deep blue, occasionally reddish-brown on sides (Mrs. G. E. MacGinitie).

Size.—Carapace length of smallest ovigerous female 6 mm.; largest female 10.7 mm; males 3.3–8 mm. Length of chela of largest female 8.5 mm.; of largest male 8 mm.

Range.—Magdalena Bay, Mexico, to Fort Bragg, Calif. (personal communication, Mr. Keith W. Cox); intertidal to depth of 12 fathoms. This is apparently a very elusive shrimp that leaves its host with little provocation, with the result that, unless precautions are taken to prevent its escape, it may be consistently missed when abalones are collected. Until Mr. Cox was consulted, no specimens had been recorded in any collections taken north of Santa Monica, even with Mr. D. Montgomery checking approximately 350 specimens of *Haliotis* from the vicinity of San Luis Obispo. On the other hand, Dr. Howard Teas, on April 4, 1953, collected at El Estero de Punta Banda, Ensenada, Baja California, Mexico, and reported to the MacGinities that about four out of every five *Haliotis fulgens* had a *Betaeus* in the mantle cavity.

693-433—63——3

HABITAT.—Found living in mantle cavity of abalone and occasionally free, latter probably temporary state, owing to disturbance of normal host. The specimens examined have occurred most commonly with the pink abalone, *Haliotis corrugata* Gray, but also with the red abalone, *H. rufescens* Swainson, the black abalone, *H. cracherodii* Leach, and the green abalone, *H. fulgens* Phillipi. Mr. Keith Cox reports them also from *H. kamtschatkana* Jonas, *H. wallalensis* Stearns, *H. sorenseni* Bartsch, and *H. assimilis* Dall.

MATERIAL.—The following specimens were examined:

MEXICO.—Magdalena Bay, Belchers Point, on shore, Jan. 30, 1938, S. A. Glassell, 1 specimen, dried.

CALIFORNIA.—La Jolla Cove, July 14, 1942, 1 female (Pacific Marine Station 845).—La Jolla, kelp beds, March 16, 1954, C. Limbaugh, 1 ovigerous female, 1 male (USNM 96414).—La Jolla, with *Haliotis rufescens* Swainson, March 28, 1952, E. Dodge, 1 ovigerous female.—San Clemente Island, living beneath mantle of *Haliotis*, January 1936, Nell Murbarger, 2 ovigerous females, 1 male (USNM 77743).—San Clemente Island, from abalone, May 8, 1888, *Albatross*, 2 females (USNM 63453).—Laguna Beach, from abalone, Sept. 19, 1918, W. A. Hilton, 1 female, deep blue (USNM 53598).—Laguna Beach, shale reef ¼ mile offshore, midway to Corona del Mar, 12 fathoms, from mantle cavity of *Haliotis corrugata* Gray, April 25, 1958, Robert Given, from N. MacGinitie, 1 ovigerous female.—Laguna Beach, off Salt Creek, 8 fathoms, from *Haliotis corrugata* Gray, May 21, 1958, Dale Seemen, from N. MacGinitie, 20 females (7 ovigerous), 5 males; May 26, 1958, 7 females (5 ovigerous).—Laguna Beach, 8 fathoms, from *Haliotis corrugata* (2 specimens from *Haliotis rufescens*), April 28, 1958, Dale Seeman, from N. MacGinitie, 4 females (1 ovigerous), 10 males.—Catalina Island, commensal in shell of green abalone, Venice Marine Biological Station, 1 ovigerous female (USNM 46119).—Catalina Island, Little Harbor, Dec. 27, 1912, *Anton Dohrn*, 2 males (USNM 49977).—San Pedro, Rocky Point, from mantle of black abalone, Feb. 2, 1912, *Anton Dohrn*, 1 ovigerous female (USNM 49975).—San Pedro, in gill chamber of *Haliotis cracherodii* Leach, June 1930, E. P. Chace, 1 ovigerous female, blue-black when alive (USNM 64087).—Santa Barbara Island, from *Haliotis rufescens*, 8 fathoms, Sept. 11, 1962, Keith W. Cox, 22 ovigerous females, 7 males.—Santa Monica Bay, Malibu Point, under mantle of *Haliotis* washed up on beach, Dec. 19, 1937, A. Camp, from R. Crocker, 1 female (Hopkins Marine Station).—Southern California, Nov. 27, 1913, *Anton Dohrn*, 1 female (USNM 49976).

NOTES.—Mr. Keith W. Cox informs me that there seems to be a definite correlation in size between the shrimps and their hosts: large shrimps in large abalones, small in small. The usual number is one shrimp per host. Exceptions do occur and on several occasions up to four have been found in the cavity between mantle and shell.

MacGinitie and MacGinitie (1949, p. 279) state:

> We have found this shrimp with its purplish-red color form living in the mantle cavity of the green abalone *Haliotis fulgens*. For over a year one has been living under the protectorate of an abalone in one of our aquariums. It usually stays with its head near the region of the mouth of the abalone, and although it is by no means inactive, its host does not give any evidence of being disturbed by its movements. On rare occasions we have seen it make short excursions onto the

shell, but it soon returns to its shelter. More frequently it may be seen on the upper surface of the frilly mantle edge of its host. At the least disturbance it hastens beneath the mantle and the abalone closes down over it in what resembles a protective manner.

In a letter, Mrs. G. E. MacGinitie states:

When the abalone diver brought in so many live *B. harfordi* we dumped about 20 of them in an aquarium with two *H. corrugata*. The next morning practically all of them had found a niche somewhere in the two abalones. But they did not all stay with the abalones very long. One per abalone is apparently normal, and soon the others were elsewhere. Six or more took refuge in the niches of the egg case of the horned shark. Another snuggled next to the third abalone in the aquarium—a specimen about an inch long, and the shrimp was at least as long as the "host."

Ovigerous females have been taken in March, April, May, September, and December. Mrs. MacGinitie reports that the eggs, when freshly laid, are nearly opaque and a pale yellowish green, becoming more transparent with development.

Betaeus macginitieae, new species

FIGURES 48, 49, 55, 62–64, 75, 76

Alpheus aequalis Holmes, 1900, p. 189 (part, specimens found on sea urchins).
Betaeus harfordi MacGinitie and MacGinitie, 1949, p. 279 (part, purple ones with sea urchins).

FEMALE.—Carapace laterally compressed but without carina; smooth, naked. Front (fig. 48) produced to form hood, which is curved slightly anteriorly but without emargination. Lateral margin (fig. 49) faintly curved, closely adhered around base of antenna without distinct anterolateral angle. Width of carapace increasing rapidly to base of maxilliped, then decreasing slightly to form curved lateral margin. Posterolateral junction rounded; posterior margin nearly straight ventral to junction of cardiac notch.

Abdomen smoothly rounded. Posterior margins of all pleura rounded but that of fifth somewhat acute. No surface setae and only pleura of first segment margined ventrally with plumose setae.

Telson (fig. 62) flattened, longer than sixth segment. About twice as wide proximally as distally. Two pairs of movable spines dorsally. Posterior margin curved, with pair of small spines (outer smaller) externally, and long plumose setae.

Eye oval, on short eyestalk with small tooth.

Antennule with stylocerite narrow, reaching to last quarter of second segment of peduncle. Peduncle with middle segment nearly twice as long as either first or third; almost bare of setae. Peduncle about ½ length of carapace. Ventrally near distal margin of first segment a stout laterally compressed tooth. Inner flagellum stout, elongate. Fused part of outer flagella stout but free tips short.

Antennal peduncle slightly longer than antennular, with ventral marginal tooth under base of scale. Flagellum flattened, somewhat longer than carapace. Scale (fig. 55) narrow: blade shorter than spine but slightly wider, separated by slit for ½ length. Reaches to nearly middle of third antennular peduncle segment.

Third maxilliped reaches to about middle of second segment of antennular peduncle. Ischiomeropodite broad, flattened, curved over mouth parts; slightly longer than other segments together. Penultimate segment shortest, armed with tufts of stiff bristles, distal segment with bands of stiff bristles on inner margin.

First legs subequal, large. Ischium short, stout. Merus stout, about twice as long as wide, triangular in cross section. Dorsal ridge smooth but ventral ridges with poorly developed setae and teeth. Carpus short, cup-shaped, naked. Chela elongate, more than twice length of merus, 2½ times as long as wide, with palm slightly longer than fingers. Blunt tooth on proximal part of fixed finger, followed by hiatus before denticulate cutting surface, which meshes with similar area on dactylus, which also has similar proximal tooth. Cutting surfaces sparsely setose. Chela somewhat flattened laterally, dorsal and ventral margins rounded, not knifelike.

Second leg (fig. 64) long, slender. Ischium slightly longer than merus, which is shorter than carpus. Carpus with first segment longest, about 1½ of fifth, which is longer than subequal second, third, and fourth segments. Fingers and palm subequal with curved bristles distally and spinulose cutting surface.

Third leg (fig. 75) with stout ischium and slightly dilated merus. Merus slightly longer than propodus, which is 1½ times length of carpus. Movable spine on proximal part of merus. Dactylus (fig. 76) short, ⅛ length of propodus, with bifid tip somewhat hidden by setae. Spines on ventral margin of carpus and propodus short but stout; one pair on carpus, many on propodus with distal pair longest.

Fourth leg similar but slightly smaller.

Fifth leg with shorter ischium. Spines on ventral margin of propodus very small, bristles of brush short. No movable spine on merus.

First pleopod with endopodite curved and ⅓ length of exopodite. Second pleopod with slender subequal exopodite and endopodite. Appendix interna stout, straplike.

Uropod (fig. 62) with posterior margin of peduncle produced into two small teeth close together, without setae. Posterolateral tooth well developed on proximal part of exopodite; spine beneath this somewhat short, stout. Uropods longer than telson.

Male.—Very similar to female, but chelipeds (fig. 63) slightly longer

in proportion. In one specimen, left side of peduncle of uropods cut into two small teeth, but right side with only one tooth. Appendix masculina bristled on distal half and on tip; twice as long as appendix interna and reaching midway between tip of appendix interna and tip of endopodite.

Color.—"Dark purple . . . resembled the color of the sea urchins in whose spines they were entangled when captured" (Holmes, 1900). "In life I have noticed no difference in the color of *B. harfordi* and the last one we are sending you from the sea urchin. For the most part, they are mostly blue, but sometimes along the side the color is a reddish brown. The claws and tail are almost always entirely blue regardless of the color along the sides of the abdomen. I could find no correlation between color and sex" (Mrs. G. E. MacGinitie, letter, 1958).

Size.—Carapace length of smallest ovigerous female 6.8 mm.; largest female 10.5 mm.; males 5.5–10 mm. Length of chela of largest female 10.3 mm.; of largest male 10.5 mm.

Range.—Santa Catalina Island to Monterey, Calif.

Habitat.—Occurs in pairs in association with sea urchins, *Strongylocentrotus franciscana* (Agassiz) and *S. purpuratus* (Stimpson).

Material.—The following specimens were examined:

California.—Santa Catalina Island, Isthmus Harbor, Nov. 27, 1913, *Anton Dohrn*, 1 ovigerous female (USNM 107546).—Laguna Beach, under *Strongylocentrotus purpuratus* (Stimpson) in hole in rock, Nov. 18, 1937, N. MacGinitie, 1 ovigerous female, 1 male.—Corona del Mar and Laguna Beach, shale reef midway between, ¼ mile offshore, 5 fathoms, from beneath *Strongylocentrotus franciscana* (Agassiz), Apr. 17, 1958, Robert Given, from N. MacGinitie, 1 ovigerous female.—Corona del Mar, Arch Rock, tide pool (may have been with purple sea urchin before being disturbed), Oct. 1932, N. MacGinitie, 1 female.—Corona del Mar, off Ladder Rock, 4 fathoms, May 22, 1958, Robert Given, from N. MacGinitie, 1 female holotype (USNM 108228).—Monterey Bay, China Point, June 1908, 2 females (1 ovigerous), 1 male (Hopkins Marine Station).

Notes.—Some specimens have the proximal part of the fingers of the chelipeds denticulate rather than with a distinct tooth. Ovigerous females have been taken in April, June, October, and November. Mrs. MacGinitie reports that the eggs, when freshly laid, are nearly opaque and a pale yellowish-green, becoming more transparent with development.

Betaeus gracilis, new species

Figures 50, 51, 56, 65–67, 77, 78

Betaeus harfordi Hilton, 1916, p. 67.

Female.—Carapace laterally compressed but without carina. Smooth, with scattered fine short setae. Setae on posterior margin

of carapace ventral to cardiac notch. Front (fig. 50) depressed, deeply indented medially, covering eyes with two hoods. Anterior margin (fig. 51) evenly curved, rounded at junction with lateral margin. Carapace increases in width to base of first legs, decreasing slightly to rounded posterior. Ventral part of posterior margin concave, then angled sharply to cardiac notch.

Abdomen smoothly rounded, bearing few scattered fine setae. Posteroventral margins of pleura of first three segments rounded, those of fourth and fifth bluntly square. Ventral margin of first pleura with plumose setae.

Telson (fig. 65) wide, flattened, longer than sixth abdominal segment. Two pairs of movable spines dorsally; posterolateral spines well developed, outer pair smaller. Posterior margin curved, bordered with bristles and plumose setae.

Eye round, with sharp tubercle on stalk.

Antennule short, stout. Stylocerite reaches nearly to end of second segment of peduncle; margins curved. Peduncle less than ½ carapace length. Slender inner flagellum scarcely as long as carapace, outer shorter, with fused portion about as long as peduncle, with four free sensory joints and slender terminal flagellum.

Antenna with peduncle longer than that of antennule. Margin of first segment produced into sharp tooth ventrally. Scale (fig. 56) broad, with stout spine, which is longer than blade and separated from it for distal third. Flattened flagellum almost as long as carapace.

Third maxilliped reaches to end of antennular peduncle. Ischiomeropodite subequal in length to last segments together (penultimate slightly shorter). Medially armed with long bristles, distal segment with bands of bristles as well. Exopodite stout, longer than ischiomeropodite.

First legs (fig. 66) subequal. Ischium short. Merus, short, wide, triangular in cross section. Smooth dorsal ridge ending distally in sharp curved tooth, with few bristles on margin. Outer ventral ridge smooth, inner with ten long bristles. Carpus cup-shaped but somewhat elongate; no setae. Chela elongate with few setae on cutting edges and tips of fingers, which are crossed over each other. Dorsal margin of hand evenly rounded, not knifelike. Palm longer than fingers, considerably less than ½ as wide as long. Little gape between fingers.

Second leg (fig. 67) slender. Ischium slightly longer than merus, together longer than carpus, which has first joint longer than fifth, and about as long as second, third, and fourth together. Chela slender, with fingers shorter than palm and with spinulate cutting surfaces.

Third leg (fig. 77) stouter than second. Merus only slightly dilated,

bearing movable spine on proximal lower margin; sparsely setose. Merus and propodus subequal in length. Spines on carpus and propodus small, with fine seta beside each spine. Narrow bifid dactylus (fig. 78) with inconspicuous setae at base of claws.

Fourth leg similar but smaller than third.

Fifth leg well developed, but ischium and merus slightly shorter than those of third leg, no movable spine present. No spines on carpus, few on propodus, but usual brush on distal part of propodus. Dactylus longer, more slender than others but similarly bifid.

First pleopod with endopodite short and round at tip. Second pleopod with endopodite subequal to exopodite, appendix interna straplike.

Uropod (fig. 65) longer than telson. Posterior margin of peduncle produced into two teeth, with setae on curved margin between. Outer tooth longer. Lateral margin of exopodite ends in small tooth covering base of large spine, nearly as long as terminal portion.

Male.—Similar to female except tip of stylocerite reaches to end of second segment of antennular peduncle. Left chela with decided gape, large triangular tooth on fixed finger, intermeshing smaller teeth on both fingers. Right chela with gape composed of round hiatuses. Second pleopod with appendix masculina bristled on distal half, terminally on blunt tip.

Color.—Pale olive-green (Hilton, 1916). Specimen label: "green eyes."

Size.—Carapace length of smallest ovigerous female 6 mm.; largest female 8 mm.; male 6 mm. Length of chela of largest female 8 mm.; of male 6 mm.

Range.—Laguna Beach to Monterey Bay, Calif.

Habitat.—Kelp holdfasts (Hilton 1916).

Material.—The following specimens were examined:

California.—Laguna Beach, W. A. Hilton, 1 ovigerous female holotype (USNM 48933), 1 ovigerous female (USNM 108230).—Pacific Grove, January 1928, G. E. MacGinitie, 1 specimen.—Monterey Bay, China Point, shore, June 1908, 1 ovigerous female, 1 male (Hopkins Marine Station).

Notes.—This species may be confused with *Betaeus setosus*, but it has much shorter antennules and antennae, is more slender and less setose. The chelae of the female from China Point are toothed like those of the male: intermeshing, with the hiatuses coinciding to form a foramen. Ovigerous females have been taken in June. The eggs are translucent green (Hilton, 1916).

***Betaeus setosus*, new species**

Figures 52, 53, 57, 68–72, 79, 80; Plate 2

Alpheus aequalis Holmes, 1900, p. 189 (part, free-living form).

Betaeus harfordi MacGinitie and MacGinitie, 1949, p. 279 (part).—Ricketts and Calvin, 1952, pp. 323–324.

FEMALE.—Carapace laterally compressed but no carina. Smooth but with scattered short setae. Tuft of longer setae under front, between eyes; cardiac notch and lower posterior margin fringed with setae. Front (fig. 52) deeply indented medially, slightly depressed but produced laterally to form "blister" over each eye. Anterior margin (fig. 53) smoothly curved. Anterolateral junction rounded. Lateral margin evenly rounded with widest part at base of first legs. Posterior margin somewhat truncate with distinct cardiac notch.

Abdomen rounded, with posteroventral margins of pleura rounded in segments one to three but angled in four and five. Ventral margin of first segment with plumose setae. Smooth with scattered setae.

Telson (fig. 68) longer than sixth segment and about 1½ times as long as widest part. Dorsal surface with scattered setae and two pairs of movable spines. Posterolateral angle with two spines: inner much larger than outer. Posterior margin rounded with bristles and plumose setae.

Eye large, round, and with sharp tooth on stout eyestalk.

Antennule with well-developed stylocerite; slender, sharp-pointed, reaching nearly to end of second segment of peduncle. First segment of peduncle produced ventrally into thin sharp tooth. Middle joint of peduncle nearly twice as long as first or third joints, whole peduncle more than ½ as long as carapace. Inner flagellum slender, about as long as carapace. Outer flagella fused for ½ its length, with long sensory setae, and terminating in short free part and long slender flagellum.

Antenna with first segment of peduncle produced ventrally into sharp tooth. Scale (fig. 57) slender; spine large, longer than blade, separated from slender blade for nearly ½ its length. Peduncle only slightly longer than that of antennule. Flagellum twice as long as carapace: flattened oval in cross section.

Third maxilliped with ischiomeropodite broad, flattened proximally, twisted. Inner margin heavily bristled, outer sparsely. Penultimate segment ½ length of distal segment, with bristles mainly on inner side. Distal segment nearly as long as ischiomeropodite, armed medially with rows of stiff bristles; reaches to end of antennular peduncle. Exopodite longer than ischiomeropodite.

First legs subequal in size. Ischium short, with sharp ridge ventrally. Merus short, stout, triangular in outline: dorsal ridge sharp, covered with soft setae; outer ridge undulate with knobs on proximal part, inner ridge tuberculate for most of its length. Broad oblique groove in which second leg rests. Distal margins of merus concave on inner side of median ridge. Joint membrane large,

making pocket into which swollen part of palm and projection of carpus fit, when "wrist" is bent. Carpus cup-shaped, with small plate ventrally, covered with long soft setae dorsally. Chela (figs. 70, 71) large, as long as carapace and nearly as wide, much compressed laterally with upper margin of base of fixed finger thin, sharp. Fixed finger twice as wide at base as dactylus, which is longer than palm. Cutting surfaces, tips of fingers, dorsal part of fixed finger setose. Left chela with large tooth medially on fixed finger, wide gape, smaller teeth intermeshing proximally and terminally before crossed corneous tips. Right chela with slight gape but most of small flat teeth intermeshing. Hands covered with fine short setae.

Second leg (fig. 72) setose with ischium and merus subequal, shorter than carpus, which has first and last joints subequal and twice as long as each of subequal median joints. Fingers almost as long as palm and finely spinulate on cutting surfaces.

Third leg (fig. 79) with stout ischium. Merus inflated with large movable spine on proximal part. Merus and propodus subequal in length. Carpus shorter than either, with pair of stout spines and setae on distal ventral margin. Propodus with stout spines and setae on ventral margin and two large spines terminally. Dactylus (fig. 80) short, broad, bifid, armed with few bristles. Whole appendage setose dorsally.

Fourth leg similar to third but somewhat smaller.

Fifth leg subequal in length to third but without movable spine on merus, no spines on carpus. Spines on propodus small, hidden by transverse bands of setae forming brush on distal third of propodus.

First pleopod with endopodite about ½ exopodite in length and width. Second pleopod with exopodite and endopodite slender, subequal. Appendix interna large, straplike.

Uropod (fig. 68) with posterior margin of peduncle produced into two large teeth; outer distinctly larger than inner. Long bristles on curved margin between teeth. Exopodite with long bristles dorsolaterally and small tooth above stout spine on posterolateral angle of proximal part. Endopodite and exopodite with scattered bristles dorsally. Uropods longer than telson.

Male.—Similar to female except that chelipeds (fig. 69) are larger in proportion, chela longer than carapace, antennular peduncle proportionately longer, abdomen somewhat narrower. First pleopod with very small endopodite. Second pleopod with appendix masculina large and bristled throughout its length. Appendix interna small.

Color.—"Nearly white" (Holmes, 1900) and red or brown with kelp, and green with sea lettuce and eelgrass (MacGinitie and MacGinitie, 1949). These were identified as *Betaeus harfordi* but probably they were *B. setosus*. Living specimens taken in British Columbia

were a uniform white or yellow in the light but became pink or orange in the dark. The change in color is due to the presence of tiny red chromatophores thickly dotted over the dorsal half of the animal (except over the eyes) and on the chelae. These expand in the dark. In some specimens there is a pale blue tinge to the chelae and the flagella. The cast skin is a very pale blue dorsally, with yellow setae on the antennal blade and on the tail fan. The chitinous tips of the dactyli of the legs are yellow.

SIZE.—Carapace length of smallest ovigerous female 4.8 mm.; largest female 8.5 mm.; males 3–7 mm. Length of chela of largest female 9 mm.; of largest male 9 mm.

RANGE.—Morro Bay, Calif., to Hecate Strait, Queen Charlotte Islands, British Columbia.

HABITAT.—The "*B. harfordi*" found under a rock at low tide (Holmes, 1900), under rocks and among seaweed (MacGinitie and MacGinitie, 1949), and on pilings (Ricketts and Calvin, 1952), were probably *Betaeus setosus*. The one specimen taken in Washington was found intertidally under a rock on the exposed west side of San Juan Island. In British Columbia, one specimen was dredged at 10 fathoms, some were found in tide pools, and others with *Pachycheles rudis* Stimpson in cavities under the holdfasts of kelp (usually *Pterygophora californica* Ruprecht) or eelgrass roots (*Phyllospadix* species). They often occur in pairs.

MATERIAL.—The following specimens were examined:

CALIFORNIA.—Morro Bay, under rocks, Feb. 1, 1939, S. A. Glassell, 2 ovigerous females.—Monterey Bay, China Point, shore, June 1908, 2 males (Hopkins Marine Station).—Monterey Bay, HMS Line Survey, No. 86, June 2, 1931, G. E. MacGinitie, 2 males (Hopkins Marine Station).—Monterey Bay, J. C. Brown, 1 ovigerous female, 1 male (USNM 23932).—Tomales Point, Dec. 26, 1939, E. F. Ricketts, 2 males.—Tomales Point, reef, *Laminaria*, June 9, 1948, 1 female, 1 male (Pacific Marine Station).—Tomales Point, ocean side, Nov. 28, 1947, 1 female, 1 male (Pacific Marine Station).—Campbell's Cove, inside entrance to Bodego Lagoon, Feb. 11, 1949, Lee O. Miles, 1 ovigerous female (Pacific Marine Station).—Dillon Beach, rocks, north, June 30, 1946, 1 ovigerous female (Pacific Marine Station).

WASHINGTON.—San Juan Island, west side, under rocks, intertidal, July 10, 1960, P. L. Illg, 1 male.

BRITISH COLUMBIA.—Vancouver Island, west coast: Clayoquot Sound, Frank Island, Cox Bay, Tofino, July 10, 1960, J. F. L. Carl, 3 ovigerous females, 1 male; Clayoquot Sound, July 29, 1961, J. F. L. Carl, 1 female holotype (USNM 108229), 5 females (3 ovigerous), 3 males; Clayoquot Sound, Round Island, June 30, 1945, E. F. Ricketts, 2 ovigerous females (USNM 80630); Clayoquot Sound, May 30, 1946, E. F. Ricketts, 1 ovigerous female, 1 male (USNM 84395); Clayoquot Sound, Deadman's Island, June 27, 1945, E. F. Ricketts, 1 ovigerous female, 1 male (USNM 80635); Esperanza Inlet, High Island, near Catala Island and Tatchu Point, June 28, 1934, E. G. Hart, 2 females (1 ovigerous), 1 male; Esperanza Inlet, Nootka Island, tide pool, July 25, 1934, E. G. Hart, 2 ovigerous fe-

males, 1 male.—Hecate Strait, Queen Charlotte Islands, 4 miles northeast Rose Point, 10 fathoms, June 24, 1956, T. H. Butler, 1 female.

NOTES.—There are a number of variations to be seen in this species. The inner ridge of the merus of the chelipeds may be almost smooth, or there may be a few tubercles, or there may be a row of uniform beadlike knobs. The dentition of the chelae varies considerably from flat intermeshed teeth, with no gape, to others with a foramen and/or a large square tooth on the fixed finger, but with the tips of the fingers always crossed (figs. 70, 71). Most have similar subequal chelae. To judge from specimens kept in the laboratory, regenerated chelae may be without teeth and a number of moults may be required to regain normal size.

Ovigerous females have been taken February–June in California and May–August in British Columbia. The ovaries and freshly laid eggs are a pale olive-green, becoming lighter and more transparent with development.

Literature Cited

BAKER, B. M.
1912. Notes on the Crustacea of Laguna Beach. 1st Ann. Rep. Laguna Marine Lab., pp. 100–117, figs. 53–64.

BANNER, ALBERT H.
1953. The Crangonidae, or snapping shrimp, of Hawaii. Pacific Sci., vol. 7, no. 1, pp. 2–147, 1 pl., 50 figs.

DANA, JAMES DWIGHT
1852; 1855. Crustacea. Vol. 13 *in* United States Exploring Expedition during the years 1838, 1839, 1840, 1841, 1842 under the command of Charles Wilkes, U.S.N. Philadelphia, part 1, 685 pp. (1852); atlas, 27 pp., 96 pls. (1855).

GLASSELL, STEVE A.
1938. New and obscure decapod Crustacea from the West American coasts. Trans. San Diego Soc. Nat. Hist. vol. 8, no. 33, pp. 411–454, pls. 27–36.

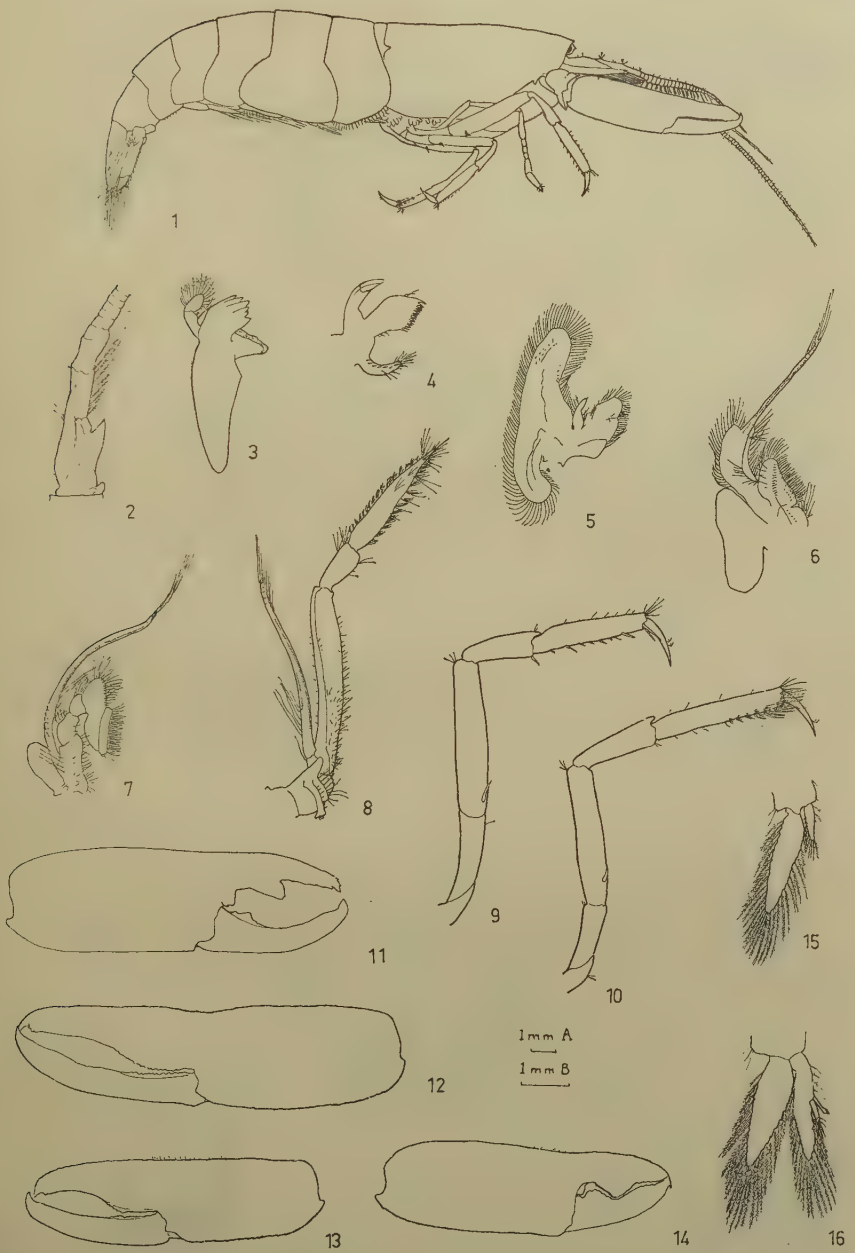
HILTON, W. A.
1916. Crustacea from Laguna Beach. Journ. Ent. Zool., Pomona College, California, vol. 8, pp. 65–73, figs. 1–19.

HOLMES, SAMUEL J.
1900. Synopsis of California stalk-eyed Crustacea. Occas. Pap. California Acad. Sci., vol. 7, 262 pp., 4 pls.

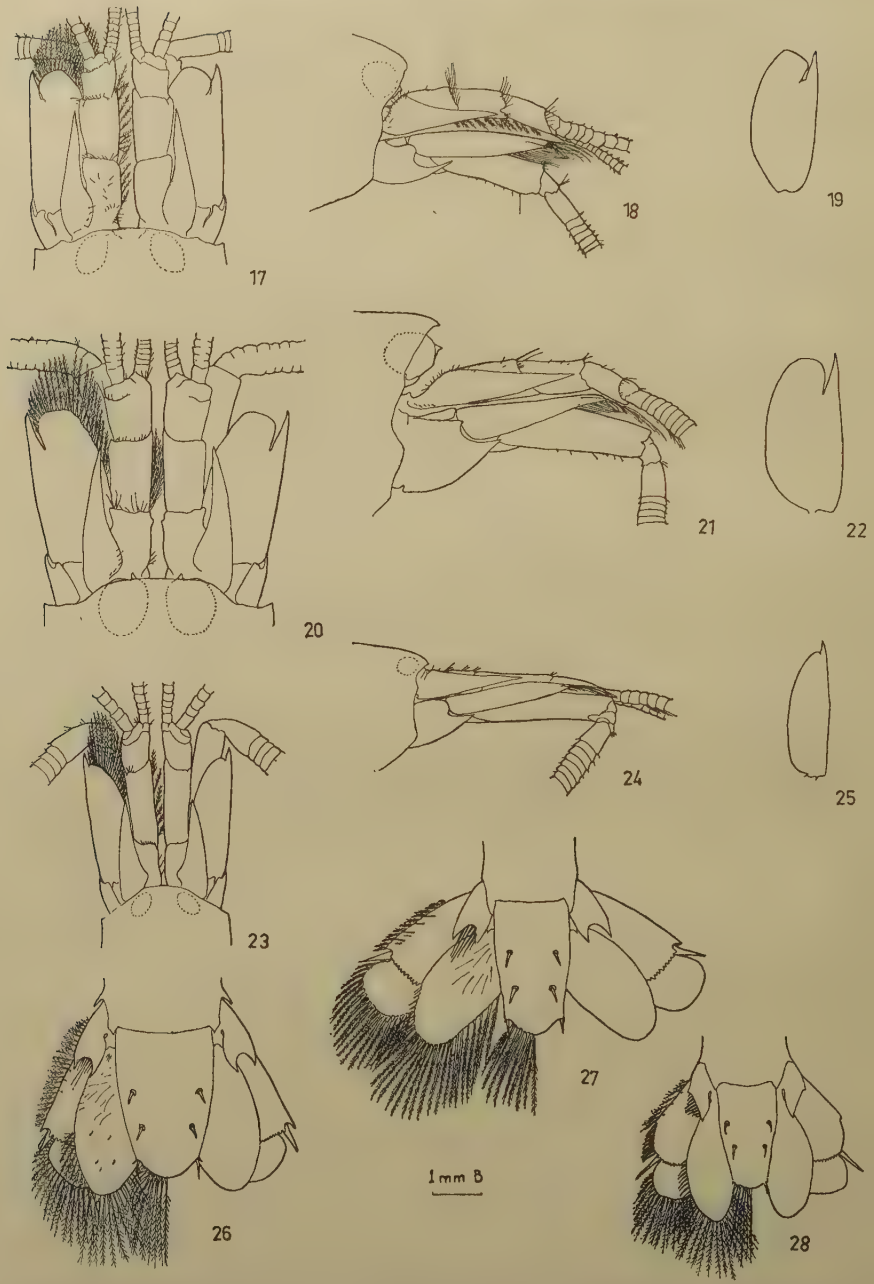
HOLTHUIS, LIPKE B.
1952. The Crustacea Decapoda Macrura of Chile. No. 5 *in* Reports of the Lund University Chile Expedition 1948–49. Lunds Univ. Årsskr., new ser., avd. 2, bd. 47, no. 10, 110 pp., 19 figs.

JOHNSON, M. E., and SNOOK, J. H.
1927. Seashore animals of the Pacific coast, 659 pp., figs.

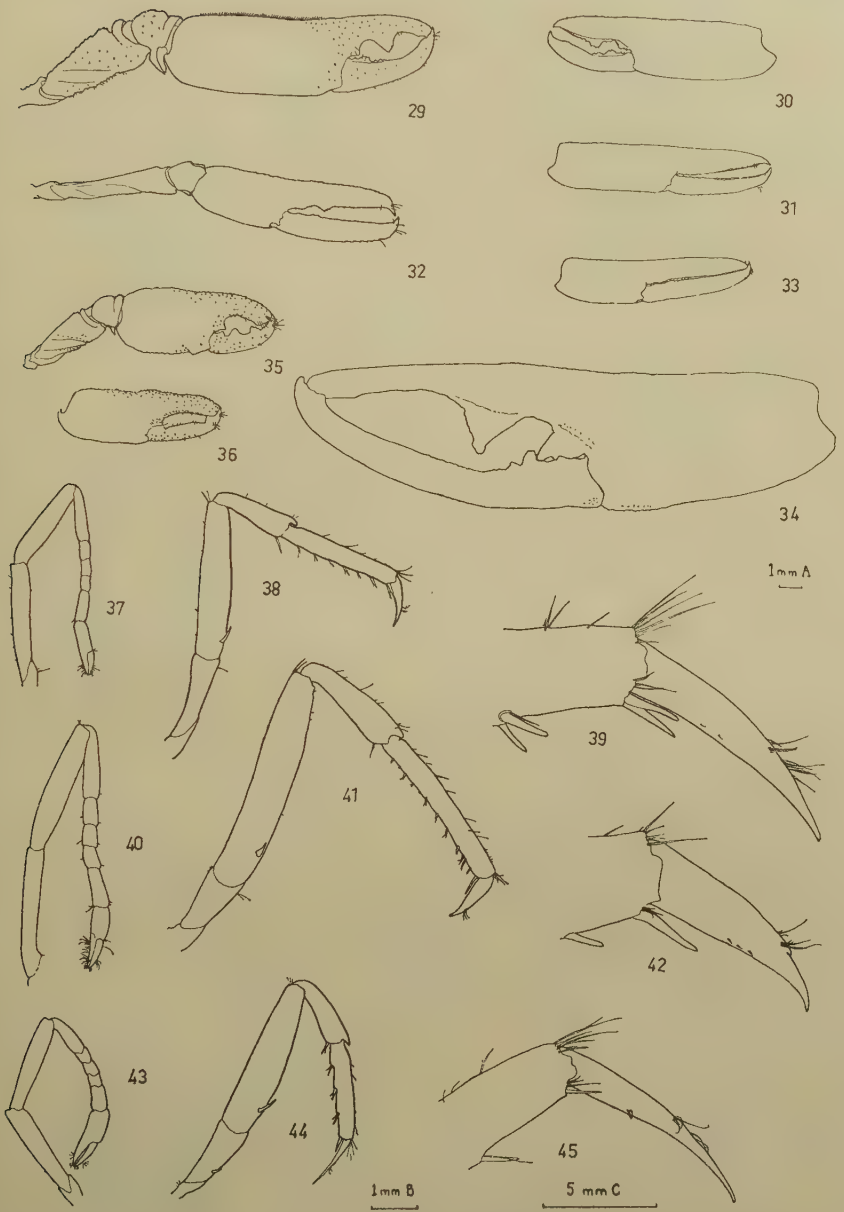
Kingsley, J. S.
1878a. A synopsis of the North American species of the genus *Alpheus*, VII. Bull. U.S. Geol. Geogr. Surv. Terr., vol. 4, no. 1, pp. 189–199.
1878b. List of the North American Crustacea belonging to the suborder Caridea. Bull. Essex Inst., vol. 10, pp. 53–70.
1882. Carcinological notes, no. V. Bull. Essex Inst. vol. 14, nos. 7–12, pp. 105–132, 2 pls.
Lockington, W. N.
1877a. Remarks on the Crustacea of the Pacific coast, with descriptions of some new species. Proc. California Acad. Sci., vol. 7, pp. 28–36.
1877b. Description of seventeen new species of Crustacea. Proc. California Acad. Sci., vol. 7, pp. 41–48.
1878. Remarks on some new Alphei, with a synopsis of the North-American species. Ann. Mag. Nat. Hist., ser. 5, vol. 1, no. 6, pp. 465–480.
MacGinitie, G. E.
1930. Notice of extension of range and of new species of various invertebrates. Ann. Mag. Nat. Hist., ser. 10, no. 6, p. 68.
1934. The natural history of *Callianassa californiensis* Dana. Amer. Midl. Nat., vol. 15, no. 2, pp. 166–177, pls. 5–6.
1935. Ecological aspects of a California marine estuary. Amer. Midl. Natur., vol. 16, no. 5, pp. 629–765, figs. 1–21.
1937. Notes on the natural history of several marine Crustacea. Amer. Midl. Natur., vol. 18, no. 6, pp. 1031–1037, 1 pl.
MacGinitie, G. E., and MacGinitie, Nettie
1949. Natural history of marine animals, 473 pp., 282 figs.
Rathbun, M. J.
1904. Decapod crustaceans of the northwest coast of North America. Harriman Alaska Expedition, vol. 10, 210 pp., 10 pls, 95 figs.
Ricketts, Edward F., and Calvin, Jack.
1952. Between Pacific tides, 3rd ed., 502 pp., 134 figs., 46 pls.
Schmitt, Waldo L.
1921. The marine decapod Crustacea of California. Univ. California Publ. Zool., vol. 23, 470 pp., 165 figs., 50 pls.
1924. Crustacea (Macrura and Anomura). *In* Expedition of the California Academy of Science to the Gulf of California in 1921. Proc. California Acad. Sci., ser. 4, vol. 13, pp. 381–388.



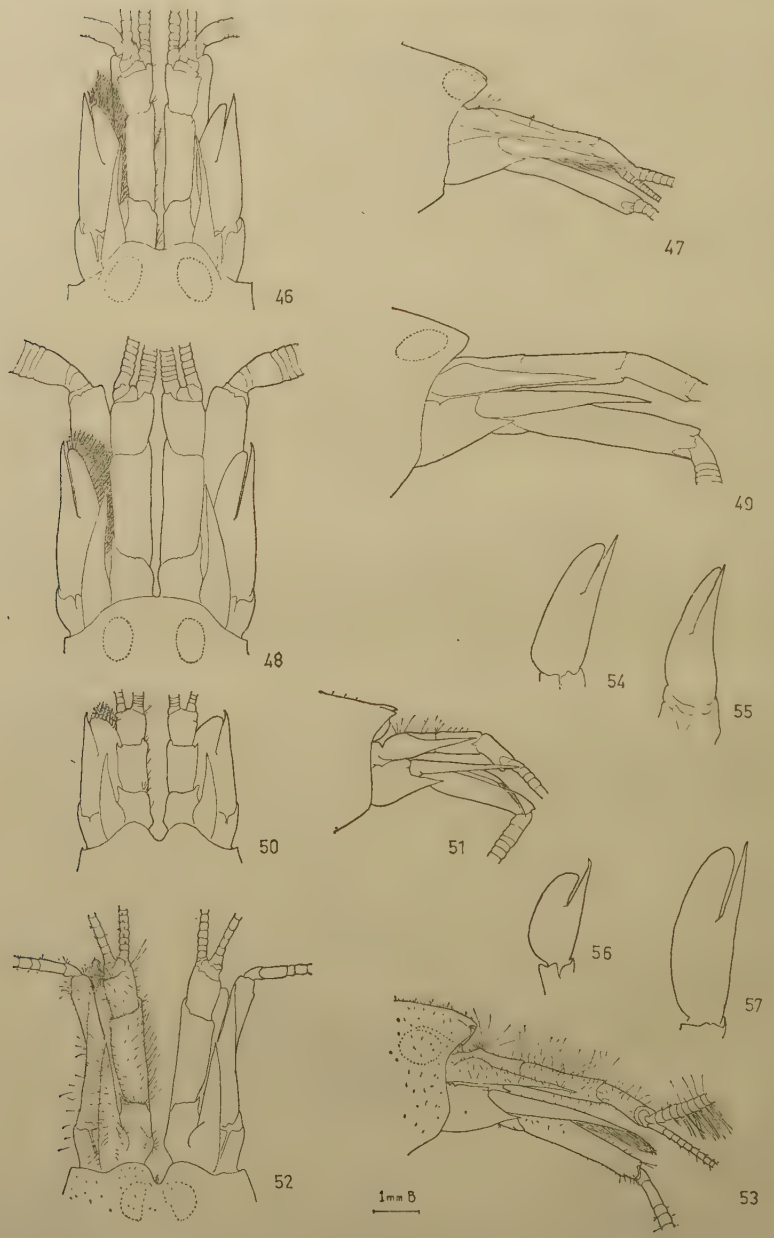
FIGURES 1–16.—*Betaeus harrimani* Rathbun: 1, lateral view; 2, antennular peduncle, lateral view; 3, mandible; 4, maxillule; 5, maxilla; 6, first maxilliped; 7, second maxilliped; 8, third maxilliped; 9, fourth leg; 10, fifth leg; 11, right chela, female; 12, left chela, male; 13, left chela, female; 14, right chela, female; 15, first pleopod, male; 16, second pleopod, male.



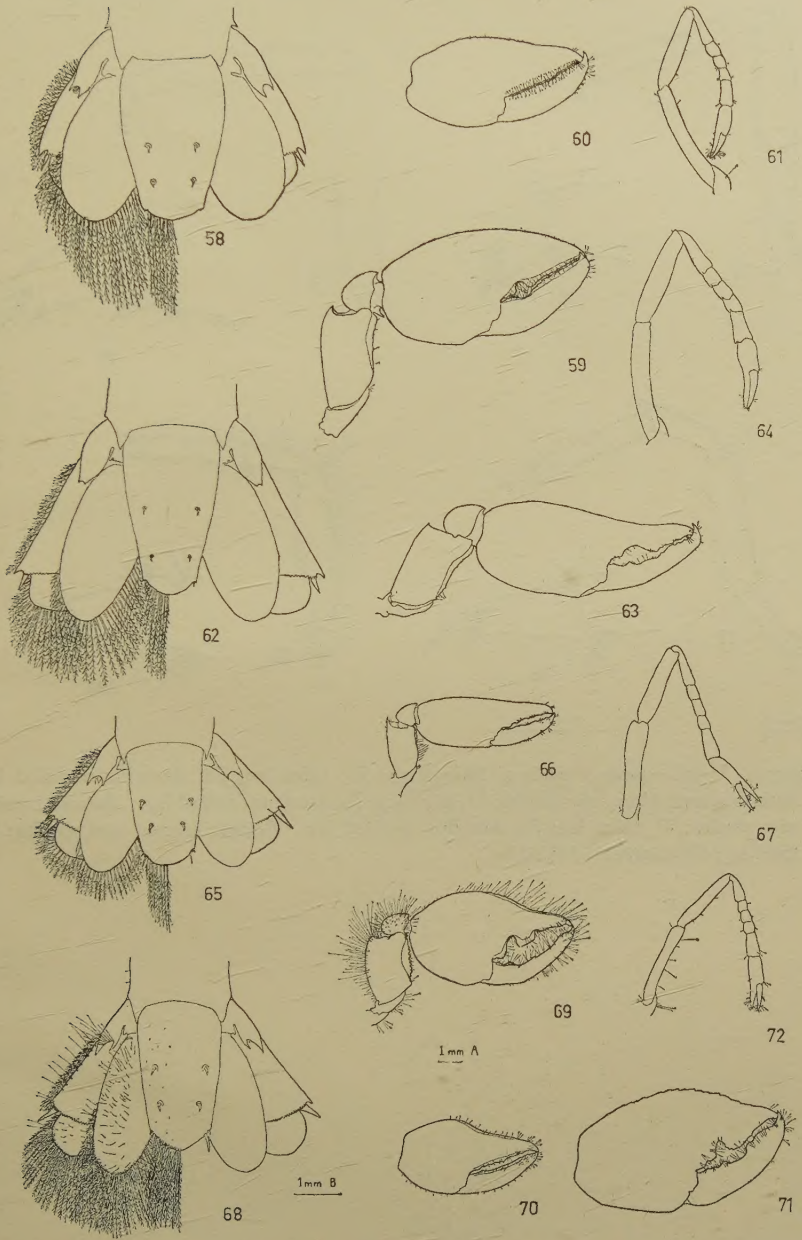
FIGURES 17–28.—*Betaeus harrimani* Rathbun: 17, frontal region, dorsal view, female; 18, same, lateral view; 19, antennal scale; 26, tail fan. *Betaeus longidactylus* Lockington: 20, frontal region, dorsal view, female; 21, same, lateral view; 22, antennal scale; 27, tail fan. *Betaeus ensenadensis* Glassell: 23, frontal region, dorsal view, male; 24, same, lateral view; 25, antennal scale; 28, tail fan.



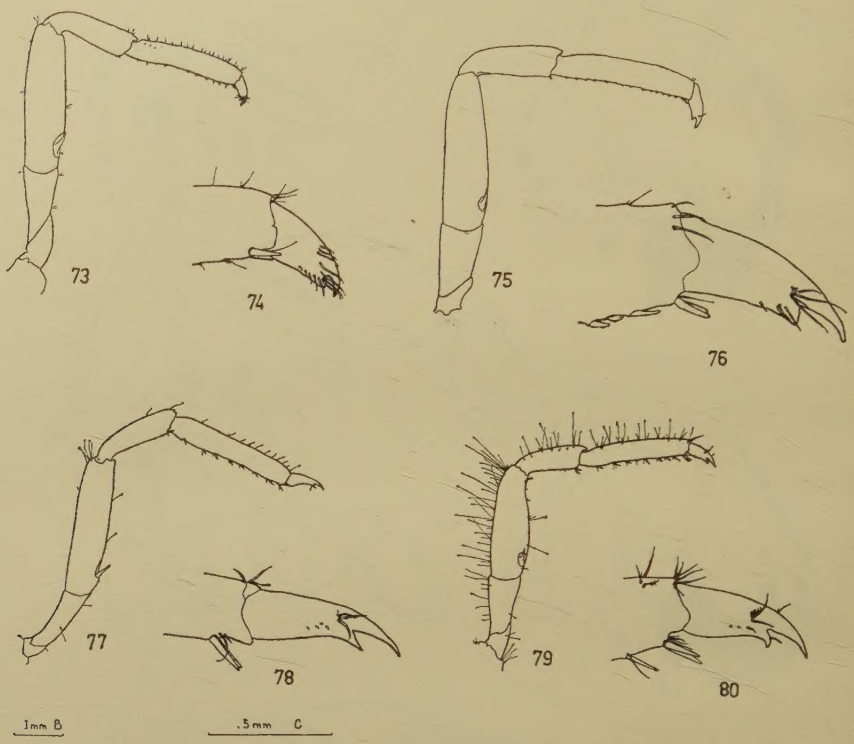
FIGURES 29–45.—*Betaeus harrimani* Rathbun: 29, right cheliped, male; 30, left chela, female; 31, right chela, same; 37, second leg; 38, third leg; 39, dactylus of third leg. *Betaeus longidactylus* Lockington: 32, right cheliped, female; 33, right chela, female; 34, left chela, male; 40, second leg; 41, third leg; 42, dactylus of third leg. *Betaeus ensenadensis* Glassell: 35, right cheliped; 36, right chela, male; 43, second leg; 44, third leg; 45, dactylus of third leg.



FIGURES 46–57.—*Betaeus harfordi* (Kingsley): 46, frontal region, dorsal view, female; 47, same, lateral view; 54, antennal scale. *Betaeus macginitieae*, new species: 48, frontal region, dorsal view, female; 49, same, lateral view; 55, antennal scale. *Betaeus gracilis*, new species: 50, frontal region, dorsal view, female; 51, same, lateral view; 56, antennal scale. *Betaeus setosus*, new species: 52, frontal region, dorsal view, female; 53, same, lateral view; 57, antennal scale.



FIGURES 58–72.—*Betaeus harfordi* (Kingsley): 58, tail fan; 59, right cheliped, male; 60, right chela, female; 61, second leg. *Betaeus macginitieae*, new species: 62, tail fan; 63, right cheliped, male; 64, second leg. *Betaeus gracilis* new species: 65, tail fan; 66, right cheliped, female; 67, second leg. *Betaeus setosus*, new species: 68, tail fan; 69, right cheliped, male; 70, right chela; 71, right chela; 72, second leg.



FIGURES 73–80.—*Betaeus harfordi* (Kingsley): 73, third leg; 74, dactylus of third leg. *Betaeus macginitieae*, new species: 75, third leg; 76, dactylus of third leg. *Betaeus gracilis*, new species: 77, third leg; 78, dactylus of third leg. *Betaeus setosus*, new species: 79, third leg; 80, dactylus of third leg.

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